

ON SOME FURTHER EVIDENCES OF GLACIATION IN THE AUSTRALIAN ALPS.

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(Communicated by C. S. Wilkinson, F.G.S.)

Since my announcement of the discovery of glacier evidences in the Mitta Mitta Valley (1), and Dr. von Lendenfeld's subsequent discovery of traces of ancient glaciers on Mt. Kosciusco (2), an interesting controversy has arisen respecting the nature and extent of such glaciation. Having recently undertaken an exploration of Mt. Bogong, the highest mountain in Victoria, in company with Dr. von Lendenfeld, for the purpose of discovering further glacier evidences, and so aiding a solution of this important question, I have much pleasure in submitting the following remarks on the results of that expedition. It may be of interest to review my connection with the controversy as a student of Physiography resident in the central part of the Australian Alps. During 1880-83, when studying the *flora* of the Australian Alps and collecting herbarium specimens for our venerable Nestor of Botanic Science, Baron von Mueller, it appeared to me that the date of the introduction of the endemic *florula* of the Australian Alps (whose affinities were so closely Tasmanian) might safely be centred in glacial movements since Miocene times, (3) provided geological evidences, which would lend support to the hypothesis, could be obtained for, as remarked by the ex-President of the Linnean Society, Mr. Wilkinson, F.G.S., F.L.S., in one of his admirable addresses to the Society (4),

(1) *J. Stirling*. On the Meteorology of the Australian Alps. Trans. Roy. Soc. Vict., 1884, p. 23.

(2) *R. von Lendenfeld*. On the Glacial Period in Australia. Proc. Linn. Soc. N.S.W., 1885, p. 45.

(3) *J. Stirling*. Remarks on Flora of Australian Alps. Southern Science Record, 1885, p. 93.

(4) *C. S. Wilkinson*. President's Address, Linn. Soc. N.S.W., Vol. IX., p. 1236.

the existence of a semi-tropic flora in South East Australia during Pliocene times and its subsequent banishment from this region is evidence of a great change of climate in Post-Pliocene times.

In a paper which I have in preparation on the geographic range of the flora of the Australian Alps, it will be shown that many species found there between 2,000 and 5,000 feet, have a wide range; recent researches on the flora of Marroca in Africa, and on that of Rurum Valley, Afghanistan, having disclosed the presence of numerous species of plants common to the Australian Alps; and as Sir Joseph Hooker remarked many years since in his splendid Essay on the Flora of Australia, "if as complete evidence of "such a proportionately cooled state of the intertropical regions "were forthcoming as there is of a glacial condition of the "temperate zones, it would amply suffice to account for the "presence of European and Arctic species in the Antarctic and "south temperate regions of both hemispheres on the mountains "of intermediate tropical latitudes." (1)

As early as 1882 I discovered many examples of what appeared to be glaciated surfaces in the higher regions of the Australian Alps, notwithstanding that in some areas there were strong evidences of powerful sub-aerial denudation and erosion having taken place during Pleistocene times. *En passant*, I may mention that these apparently glaciated surfaces were seen on the quartz porphyries of Mt. Cobboras at elevations between 4,000 and 6,000 feet; on the metamorphic rocks of Mt. Pilot on the Pilot River Valley, down to 3,000 feet; and on the granitic rocks of Mt. Kosciusco, recently photographed by Dr. von Lendenfeld. Partly, however, from inexperience of glaciated surfaces elsewhere, I hesitated to pronounce authoritatively on them as glacier evidences until further opportunities were afforded me of discovering moraines, and erratics at the lower levels. From the fact that my friend A. W. Howitt, F.G.S., had not observed any appearances which he could in any way refer to a glacial period analogous with that of the northern hemisphere unless (as he further remarks)

(1) *J. D. Hooker. Flora of Australia.*

the old lake basins near Omeo might suggest the action of ice, (1) I thought it very probable that any pre-existing evidences at the lower levels might have been scoured away by a subsequent pluvial period (2.)

The publication by my friend, Mr. G. S. Griffith, of a paper on evidences of a glacial epoch in Victoria during Post-Miocene times (3), induced me to re-examine the evidences at the higher altitudes, and to endeavour to follow the traces to lower levels in the Indi and Mitta Mitta Valleys, with the result that I felt justified in making the announcement previously referred to on 11th December, 1884, even though some of the phenomena therein ascribed to glacier action might be found on closer scrutiny to have been produced by other causes. The indications taken as a whole were sufficient in my opinion to justify the hypothesis of glaciation, for on no other conceivable theory, as it appeared to me, could the facts as a whole be accounted for, while refrigeration of the area and the consequent production of glaciers in the valleys of the Australian Alps over wide areas would harmonise with conclusions deducible from an examination of the flora and fauna. In the beginning of January 1885, Dr. von Lendenfeld ascended Mt. Kosciusco and photographed some glaciated surfaces. From the absence of any reference to my previous announcements save a mere reference from "Southern Science Record," to the snow patches at the higher regions of the Australian Alps, I inferred that Dr. von Lendenfeld was unaware of my previous writings and discoveries, or he would not have stated in his interesting paper on the glacial period in Australia, read before the Linn. Soc. of N.S.W. during January 1885, that the glacial area was limited to 100 square miles above 5,800 feet altitude. (4) On 9th July I published in the Trans. Roy. Soc. Victoria, the first of an intended series of papers on the evidences of glaciation in the Australian Alps,

(1) *A. W. Howitt, F.G.S.* Geology of North Gippsland. Q.J.G.S. Lond., vol. 35, p. 35.

(2) *J. Stirling, F.L.S.* On a Geol. Sketch Section through the Australian Alps. Trans. Roy. Soc., S.A., 1884.

(3) *G. S. Griffiths.* On Evidences of a Glacial Epoch in Vict. during Post Miocene times. Trans. Roy. Soc. Vict., 1884.

(4) *R. von Lendenfeld, Ph.D.* On the Glacial Period in Australia. Proc. Linn. Soc., N.S.W., 1885.

detailing certain phenomena in the Livingstone Creek and Victoria River Valleys. (1) During the same month a paper by Captain, now Professor Hutton, F.G.S. of New Zealand, was read before the Linnean Society of N.S.W., on the supposed glacial epoch in Australia (2), being in part a reply to Dr. von Lendenfeld's previous writings concerning a very recent glacier epoch in the Southern Hemisphere, based upon New Zealand experiences and explorations, and partly an endeavour to show that the *roches moutonnées* and smoothed surfaces on Mt. Kosciusco by no means imply, or to use the actual words of the learned Professor, "it" "by no means follows that they were caused by a glacial epoch, "because they might equally well be due to greater elevation, "combined with greater atmospheric moisture." We are also advised to "distrust an attempt to explain an *isolated phenomenon* by means of a wide-spread cause." Now it appears to me that Captain Hutton would not have assumed the isolation of the phenomena if he had been fully acquainted with the literature of the subject, and especially my announcement previously referred to. I do not propose to join issue with him in respect to the distinction he seeks to draw between a "glacier epoch" and a "glacial epoch," but merely to show that the phenomena of glaciation are not so isolated as his remarks would lead one to suppose he believes them to be. I am led to make these remarks, because as a student of Physiography I feel very much indebted to Prof. Hutton for the valuable information supplied by his writings concerning the geological structure, flora, fauna, and climatology of New Zealand, and I should be sorry to know that he laboured under any misapprehension as to the nature and extent of the evidences of glaciation in the Australian Alps. Following the publication of the papers of myself and Prof. Hutton we have one by Prof. Tate, F.G.S., of South Australia, (3) read before the Royal Society of that colony, in which are stated very clearly the

(1) *J. Stirling, F.G.S., F.L.S.* On the Evidence of Glaciation in the Australian Alps. Trans. Roy. Soc. Vict., 1885.

(2) *Prof. Hutton, F.G.S.* On the supposed Glacial Epoch in Australia. Proc. Linn. Soc., N.S.W., 1885.

(3) *Prof. Tate, F.G.S.* On Post-Miocene Climate in South Australia. Trans. Roy. Soc. S.A., 1885.

evidences in favour of a glacial period in South Australia. The objections by Mr. Scoullar, Cor. Mem., as to the origin of the glaciated surfaces near Adelaide, viz., that they were caused "by the attrition of blown sand," are also controverted. I have seen some photographs of these glaciated surfaces, (sent to me for inspection by Prof. Tate) and they resemble very strongly the glaciated surfaces on Mts. Cobboras and Bogong, to be herein-after referred to. Dr. von Lendenfeld has also seen some photographs of polished rocks from South Australia, and has no doubt as to the glacier origin of the polishing, (1) although he doubts whether the striae referred to are isochrone with the glacial traces he discovered on Mt. Kosciusco. In consequence of a very interesting correspondence on the subject of glacier evidences between Dr. von Lendenfeld and myself, it was arranged that we should make a joint trip to the highest mountain in Victoria, Mt. Bogong, and if time and circumstances permitted, explore the Bogong High Plains to the south, and proceed thence along the main dividing range towards Mt. Kosciusco, so that his extensive European Alpine experience and my local geological knowledge might be utilized, and the features discussed on the ground. On the 3rd January, 1886, we met at Snowy Creek junction and tributary of the Mitta, and on the following three days made the ascent of Mt. Bogong from the north, an arduous journey but still of great interest. Dr. von Lendenfeld has already described our journey in the publications of the Mining Department of Victoria (Mining Registrar's Returns for Quarter ended March), so that it is unnecessary for me to repeat the narrative. Suffice it to say that the evidences of glaciation discovered by us are—

1. Erratics in the Reewa River and Snowy Creek Valleys.
2. *Blocs perches* and smoothed surfaces on Mt. Bogong.
3. Moraines at base of Mt. Bogong, Mountain Creek in Reewa River Valley.

The first named are very abundant in the Pleistocene drifts at Snowy Creek, consisting of huge basaltic boulders, etc., in linear

(1) *R. von Lendenfeld*. Note on the Glacial Period in Australia. Proc. Linn. Soc. N.S.W., Vol. X., p. 330.

extension for miles, as at Granite Flat—the nearest basaltic outliers being fully 20 miles distant on Bogong High Plains, etc.

The second or what I have called *blocs perches* are large, semi-rounded or sub-angular masses of igneous or rather plutonic rock—hornblende porphyrites—occupying the crests of spurs and sidelings in a regular descending series from near the summit of Mt. Bogong 6,508 feet, towards the Reewa Valley, many of them resting upon smoothed surfaces of pegmatite at lower levels. (Mt. Bogong is gneissic.)

The last named are huge masses of angular and sub-angular rocks at the base of Mt. Bogong, pronounced by Dr. von Lendenfeld to be undoubted moraines (at an elevation of 1,000 feet above sea level). I may remark that these masses are too extensive and distant from the steep spurs of Mt. Bogong to be considered as *talus*; besides which they show evidences of translocation.

I do not purpose entering into a description of further evidences discovered by myself in the Mitta Mitta Valley, at Lake Omeo, or Benambia Creek, etc., in the present paper. There will in due course be communicated a second article on the evidences of glaciation in the Australian Alps, together with a reply to later criticisms. I merely desire to show that the evidences discovered on Mt. Kosciusco by Dr. von Lendenfeld are by no means isolated, and that the highest mountain in Victoria, Mt. Bogong, presents features which confirm the evidences of glaciation elsewhere, and that there is no *a priori* impossibility of the area of glaciation being more extensive than has been assumed. In conclusion, I would add that taking into consideration the facts supplied to us by the examination of the ancient flora and fauna of Australia as contained in the writings of Prof. Tate of South Australia and of Mr. Wilkinson, F.G.S., of New South Wales, and the geological evidences of glaciation over widespread areas daily accumulating, it is difficult indeed to resist the conviction that Southern Australia, as well as South America and Southern Africa, and indeed New Zealand, all participated in a period of refrigeration, culminating in an ice-clad region during later Pliocene or Pleistocene times, notwithstanding that many difficulties suggest themselves in endeavouring to work out the problem from mere localized observations.